Appendix E

Answers to Odd-Numbered Problems

Chapter 1

1.1 (a) -0.1038 C, (b) -0.19865 C, (c) -3.941 C, (d) -26.08 C

1.3 (a) $3t + 1$ C, (b) $t^2 + 5t$ mC, (c) $2\sin(10t + \pi/6) + 2\ \mu$C, (d) $-e^{-30t}[0.16\cos 40t + 0.12\sin 40t]$ C

1.5 490 μC

1.7 $$i = \begin{cases} 25 \text{ A}, & 0 < t < 2 \\ -25 \text{ A}, & 2 < t < 6 \\ 25 \text{ A}, & 6 < t < 8 \end{cases}$$

See the sketch in Fig. E.1.

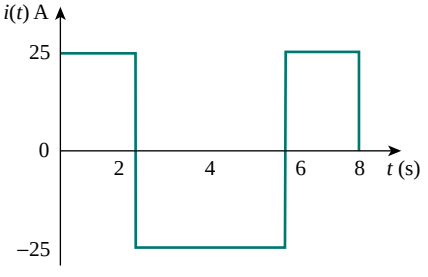


Figure E.1 For Prob. 1.7.

1.9 (a) 10 C, (b) 22.5 C, (c) 30 C

1.11 (a) 2.131 C, (b) -8.188 W

1.13 916.7 mJ

1.15 $P_1 = -300$ W, $P_2 = 100$ W, $P_3 = 200$ W, $P_4 = -32$ W, $P_5 = -48$ W

1.17 18 V

1.19 (a) 60 W, 100 W, (b) 4 W, (c) 110 W, (d) 700 W, (h) 350 W

1.21 21.6 cents

1.23 (a) 43 kC, (b) 475.2 kJ, (c) 1.188 cents

1.25 39.6 cents

1.27 750 ks

1.29 (a) 10.4 kWh, (b) 433.3 W/h

1.31 (a) 4 A, (b) 1.852 days

1.33 13.43×10^6 J

Chapter 2

2.1 3.2 mA

2.3 20.8 μS

2.5 $n = 9, b = 15, l = 7$

2.7 7 branches and 5 nodes

2.9 11 A, 4 A, 1 A

2.11 -4 V, -6 V, 4 V, -2 V

2.13 14 V, 22 V

2.15 4 A, 28 V

2.17 4 A

2.19 -4.444 V, 98.75 W

2.21 0.1 A, 2 kV, 0.2 kW

2.23 6 V, 18 V

2.25 12 V, 3 A, 0 A, 0 V

2.27 10 V, 1 A, 4 W

2.29 3 V, 6 A

2.31 8 V, 0.2 A

2.33 12 Ω

2.35 (a) 0 A, (b) R, (c) R, (d) R, (e) $\frac{6}{11}R$

2.37 16 Ω

2.39 (a) 12 Ω, (b) 16 Ω

2.41 (a) 76 Ω, (b) 54 Ω

2.43 (a) $R_a = R_b = R_c = 30\ \Omega$, (b) $R_a = 103.3\ \Omega$, $R_b = 155\ \Omega$, $R_c = 62\ \Omega$

2.45 889 Ω

2.47 (a) 125 Ω, (b) 275 Ω

2.49 0.9974 A

2.51 12.21 Ω, 1.64 A

2.53 1.2 A

2.55 Use R_1 and R_2 bulbs

2.57 11 Ω, 99 Ω

2.59 (a) 800 kΩ, (b) 2 mW

2.61 (a) 100 mA, (b) 975.6 mA, (c) 2.44 %

2.63 45 Ω

2.65 (a) 19.9 kΩ, (b) 20 kΩ

2.67 (a) Four 20-Ω resistors in parallel.
(b) One 300-Ω resistor in series with a 1.8-Ω resistor and a parallel combination of two 20-Ω resistor.
(c) Two 24-kΩ resistors in parallel connected in series with two 56-kΩ resistors in parallel.
(d) A series combination of a 20-Ω resistor, 300-Ω resistor, 24-kΩ resistor and a parallel combination of two 56-kΩ resistors.

2.69 75 Ω

2.71 38 kΩ, 3.33 kΩ

2.73 375 Ω, 257.1 Ω

Chapter 3

3.1 9.143 V, −10.286 V, $p_{8\Omega} = 10.45$ W, $p_{4\Omega} = 94.37$ W, $p_{2\Omega} = 52.9$ W

3.3 4 A, 2 A, 1.333 A, 0.667 A, 40 V

3.5 20 V

3.7 2.778 V

3.9 −4 A

3.11 1.072 A, 2.041 A

3.13 20 V

3.15 18.86 V, 6.286 V, 13 V

3.17 10 V, 20 V, 20 V

3.19 −10.91 V, −100.36 V

3.21 20 V, 0 A

3.23 −1.344 kV, −5.6 A

3.25 2 V, 12 V, −8 V

3.27 (a) planar, redrawn as shown in Fig. E.2, (b) nonplanar

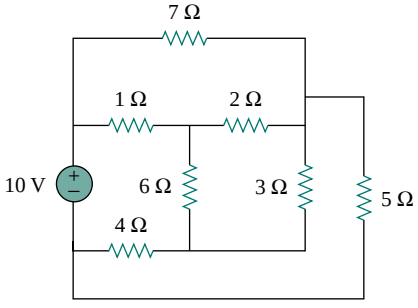


Figure E.2 For Prob. 3.27(a).

3.29 8.727 V

3.31 3.652 V

3.33 1.188 A

3.35 −1.733 A

3.37 33.78 V, 10.67 A

3.39 20 V

3.41 1.072 A, 2.041 A

3.43 6 V, 6 V

3.45 −1.344 kV, −5.6 A

3.47 −0.3

3.49 −4 V, 2.105 A

3.51
$$\begin{bmatrix} 1.25 & -1 \\ -1 & 1.5 \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} 3 \\ -1 \end{bmatrix}$$
$V_1 = 4$ V, $V_2 = 2$ V

3.53 $\begin{bmatrix} 1.75 & -0.25 & -1 \\ -0.25 & 1 & -0.25 \\ -1 & -0.25 & 1.25 \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} 20 \\ 5 \\ 5 \end{bmatrix}$

3.55 $\begin{bmatrix} 6 & -2 & -0 \\ -2 & 12 & -2 \\ 0 & -2 & 7 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \\ i_3 \end{bmatrix} = \begin{bmatrix} 12 \\ -8 \\ -20 \end{bmatrix}$, 6.52 W

3.57 $\begin{bmatrix} 9 & -3 & -4 & 0 \\ -3 & 8 & 0 & 0 \\ -4 & 0 & 6 & -1 \\ 0 & 0 & -1 & 2 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \\ i_3 \\ i_4 \end{bmatrix} = \begin{bmatrix} 6 \\ 4 \\ 2 \\ -3 \end{bmatrix}$

3.59 −1 A, 0 A, 2 A

3.61 −3 A, 0 A, 3 A

3.63 26.667 V, 6.667 V, 173.3 V, −46.67 V

3.65 See Fig. E.3; −12.5 V

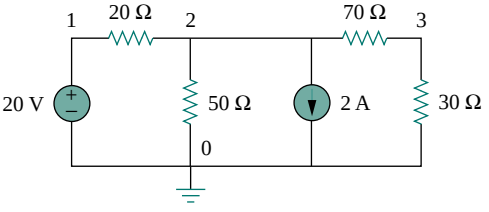


Figure E.3 For Prob. 3.65.

3.67 −0.187 V

3.69 −80

3.71 5.23 V

3.73 12.296 μA, 5.791 V

Chapter 4

4.1 0.1, 1 A

4.3 (a) 0.5 V, 0.5 A, (b) 5 V, 5 A, (c) 5 V, 0.5 A

4.5 4.5 V

4.7 −1.32 A, 17.43 W

4.9 3 A

4.11 8 V

4.13 0.1111 A

4.15 −0.1176 A

4.17 3 A

4.19 0.555 A

4.21 −8.57 V

4.23 0.1111 A

4.25 3.652 V

4.27 (a) 8 Ω, 16 V, (b) 20 Ω, 50 V

4.29 −0.125 V

4.31 2.5 Ω, 6 V

4.33 10 Ω, 10 V

4.35 (a) 3.857 Ω, 4 V, (b) 3.214 Ω, 15 V

4.37 (a) 8 Ω, 2 A, (b) 20 Ω, 2.5 A

4.39 28 Ω, 3.286 A

4.41 (a) 2 Ω, 7A, (b) 1.5 Ω, 12.67 A

4.43 3 Ω, 1A

4.45 1.875 A

4.47 $-\dfrac{R_2[R_1(1+\beta)R_2]}{\beta(R_1+R_2)}$

4.49 $R_{\text{Th}} = R_{\text{N}} = 3.333\ \Omega$, $V_{\text{Th}} = 10$ V, $I_{\text{N}} = 3$ A

4.51 31.73 Ω, 0 V

4.53 −1 Ω V, 0 V

4.55 7.2 Ω, 1.25 W

4.57 −1.187 kW

4.59 (a) 12 Ω, 40 V, (b) 2 A, (c) 12 Ω, (d) 33.33 W

4.61 1 kΩ

4.63 (a) 3.8 Ω, 4 V, (b) 3.2 Ω, 15 V

4.65 10 Ω, 167 V

4.67 3.333 Ω, 10 V

4.69 8 Ω, 12 V

4.71 (a) 10 mA, 8 kΩ, (b) 9.926 A

4.73 (a) 100 Ω, 20 Ω, (b) 100 Ω, 200 Ω

4.75 $\dfrac{V_s}{R_s + (1+\beta)R_o}$

4.77 5.333 V, 66.67 kΩ

4.79 2.4 kΩ, 4.8 V

Chapter 5

5.1 (a) 1.5 MΩ, (b) 60 Ω, (c) 98.06 dB

5.3 10 V

5.5 0.9999990

5.7 −100 nV, −10 mV

5.9 (a) 2 V, (b) 2 V

5.11 −2 V, −1 mA

5.13 2.7 V, 288 μA

5.15 (a) Proof, (b) −35

5.17 -11.764

5.19 -1.6364

5.21 If $R_1 = 10\ \text{k}\Omega$, then $R_f = 150\ \text{k}\Omega$

5.23 (a) 10.2, (b) $1.471 \cos 120\pi t$

5.25 100 μA, 2 μW

5.27 600 nA, 12 mV, 2.4 nW

5.29 If $R_1 = 10\ \text{k}\Omega$, then $R_f = 90\ \text{k}\Omega$

5.31 -120 mV

5.33 3 kΩ

5.35 See Fig. E.4, where $R \leq 100\ \text{k}\Omega$.

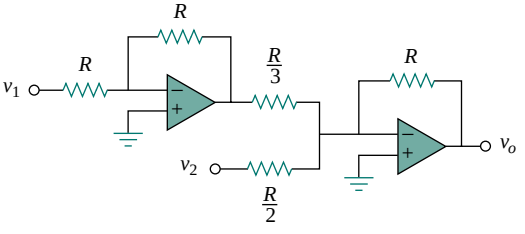


Figure E.4 For Prob. 5.35.

5.37 -2 V, -2.4 mA

5.39 $R_1 = R_3 = 10\ \text{k}\Omega$, $R_2 = R_4 = 20\ \text{k}\Omega$

5.41 See Fig. E.5.

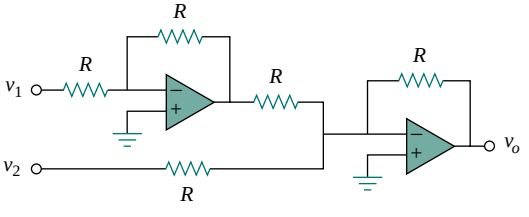


Figure E.5 For Prob. 5.41.

5.43 (a) 300, (b) 3.333

5.45 (a) 36 μA, (b) $30 \cos 377t\ \mu$A

5.47 -1.333

5.49 $\dfrac{R_2 R_4}{R_1 R_5} v_1 - \dfrac{R_4}{R_5} v_2$

5.51 $\dfrac{R_2 R_4 / R_1 R_3 - R_4 / R_6}{1 - R_2 R_4 / R_3 R_5}$

5.53 2.4 V

5.55 -17.14 mV

5.57 -1 V

5.59 100 μA

5.61 -374.8 μA

5.63 0.6677 V

5.65 12 V

5.67 0.25 V

5.69 (a) Proof, (b) 0.825 V, (c) 0.375 V

5.71 (a) -3.2 V, (b) 1.8 V

5.73 14.67

5.75 5

5.77 5.5

Chapter 6

6.1 $10(1-3t)e^{-3t}$ A, $20t\,(1-3t)e^{-6t}$ W

6.3 0.48 A

6.5 $v = \begin{cases} 100t^2 \text{ kV}, & 0 < t < 1 \\ 100(4t - t^2 - 2) \text{ kV}, & 1 < t < 2 \end{cases}$

6.7 $0.04t^2 + 10$ V

6.9 See Fig. E.6.

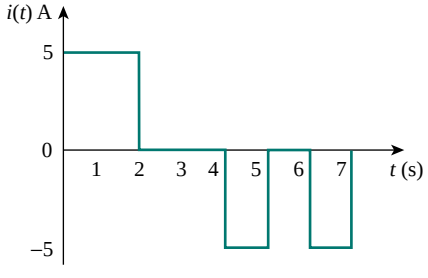


Figure E.6 For Prob. 6.9.

6.11 $-0.72\pi \sin 4\pi t$ A, -5.4 J

6.13 (a) 120 mF, (b) 7.5 mF

6.15 (a) 3 F, (b) 8 F, (c) 1 F

6.17 4 mF

6.19 50 μF

6.21 (a) $V_{30} = 90$ V, $V_{60} = 30$ V, $V_{14} = 60$ V, $V_{20} = 48$ V, $V_{80} = 12$ V,
(b) $W_{30} = 121.5$ mJ, $W_{60} = 27$ mJ, $W_{14} = 25.2$ mJ, $W_{20} = 23.04$ mJ,
$W_{80} = 5.76$ mJ

6.23 (a) 35 μF, (b) 0.75 mF, 1.5 mC, 3 mC, (c) 393.4 J

6.25 22.39 μF

6.27 $v_o(t) = \begin{cases} 10t^2 \text{ kV}, & 0 < t < 1 \\ 40t - 10t^2 - 20 \text{ kV}, & 1 < t < 2 \end{cases}$

6.29 (a) 8 V, (b) $-480e^{-3t}$ μA, $-6 + 8e^{-3t}$ μA, (c) $-480e^{-3t}$ μA, $-180e^{-3t}$ μA, $-300e^{-3t}$ μA

6.31 0.2 H

6.33 $4.8 \cos 100t$, 96 mJ

6.35 5.977 A, 35.72 J

6.37 144 μJ

6.39 $i(t) = \begin{cases} 0.25t^2 \text{ kA}, & 0 < t < 1 \\ 1 - t + 0.25t^2 \text{ kA}, & 1 < t < 2 \end{cases}$

6.41 5 Ω

6.43 (a) 7 H, (b) 3 H, (c) 2 H

6.45 7.778 H

6.47 7 H

6.49 $\frac{5}{8}$ L

6.51 See Fig. E.7.

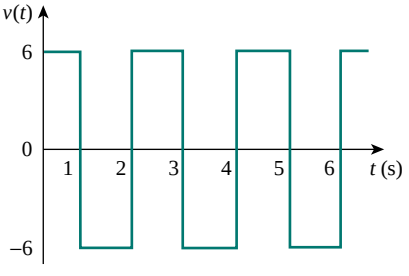


Figure E.7 For Prob. 6.51.

6.53 (a) 2 mA, (b) $2.4e^{-2t}$ mA, $3.6e^{-2t}$ mA, (c) $-0.12e^{-2t}$ mV, $-0.144e^{-2t}$ mV, (d) $W_{10} = 24.36$ nJ, $W_{30} = 11.693$ nJ, $W_{20} = 17.54$ nJ

6.55 $50(1 - \cos 4t)$ mA, $4.8 \sin 4t$ mV

6.57 6s

6.59 One possibility is letting $R = 100$ kΩ, then $C = 0.2$ μF

6.61 5.625 mV

6.63 See Fig. E.8.

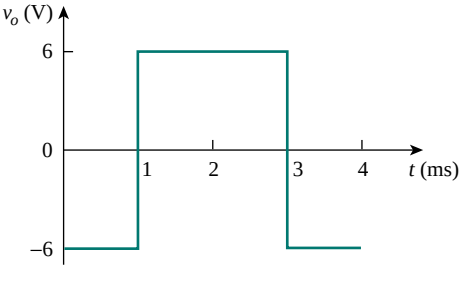


Figure E.8 For Prob. 6.63.

6.65 See Fig. E.9.

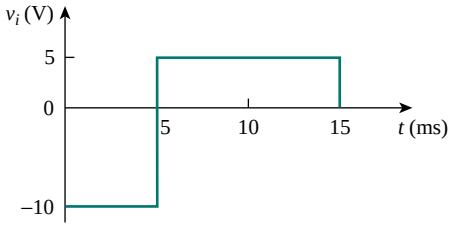


Figure E.9 For Prob. 6.65.

6.67 See Fig. E.10.

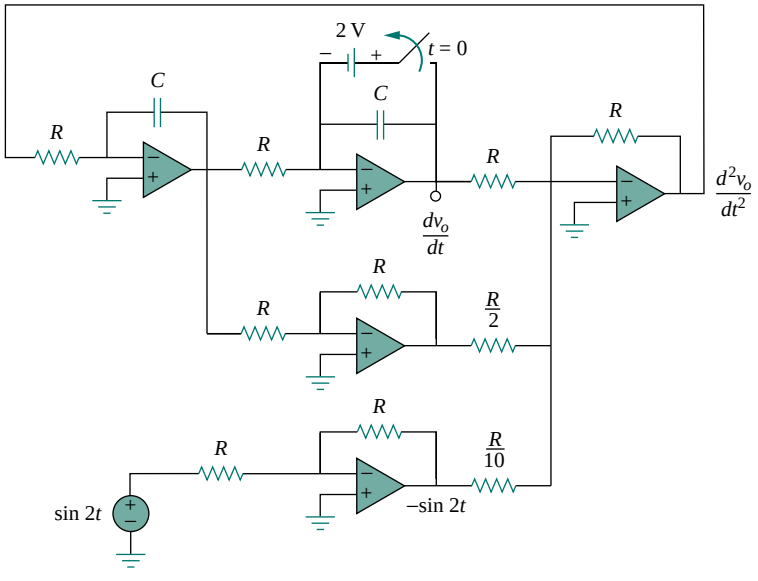


Figure E.10 For Prob. 6.67.

6.69 $\dfrac{d^2v_o}{dt^2} + 5\dfrac{dv_o}{dt} + 2v_o = f(t)$

6.71 150 nF

6.73 (a) 1250 μF, (b) 400 J

Chapter 7

7.1 Proof

7.3 6 ms

7.5 1.195 V

7.7 (a) 50 Ω, 5 mF, (b) 0.25 s, (c) 250 mJ, (d) 86.6 ms

7.9 $3e^{-10t}$ A

7.11 $4e^{-2t}$ A

7.13 2 μs

7.15 $-2e^{-16t}$ V

7.17 $2e^{-5t}$ A

7.19 13.33 Ω

7.21 $2e^{-4t}$ V, $t > 0$, $0.5e^{-4t}$ V, $t > 0$

7.23 (a) $u(t+1) - 2u(t) + u(t-1)$,
(b) $2u(t-2) - r(t-2) + r(t-4)$,
(c) $2u(t-2) + 2u(t-4) - 4u(t-6)$,
(d) $-r(t-1) - u(t-1) + r(t-2) + 2u(t-2)$

7.25 See Fig. E.11.

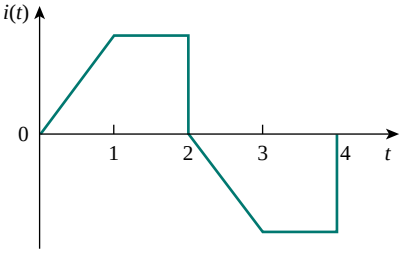


Figure E.11 For Prob. 7.25.

7.27 (a) 112×10^{-9}, (b) 7

7.29 (a) $-2e^{-5t/3}$ V, (b) $5e^{2t/3}$ V

7.31 (a) 4 V, $t < 0$, $20 - 12e^{-t/8}$, $t > 0$, (b) 4 V, $t < 0$, $12 - 8e^{-t/6}$ V

7.33 $10(1 - e^{-0.2t})$ V

7.35 0.8 A, $0.8e^{-t/160}$ A

7.37 $1.25(1 - e^{-t/5})$ V, $0.125e^{-t/5}$ A

7.39 $10e^{-t/3}$ V, $-\frac{1}{3}e^{-t/3}$ A

7.41 $7.5(3 - e^{-4t})$ mA, $t > 0$

7.43 2 A

7.45 (a) 1 A, $\frac{1}{7}(6 - e^{-2t})$ A, (b) 2 A, $3 - e^{-9t/4}$ A

7.47 $-4e^{-20t}$ V

7.49 $15 + 5e^{-16t}$ V

7.51 $16e^{-0.5t}$ V

7.53 $$i(t) = \begin{cases} \frac{1}{6}(1 - e^{-t}) \text{ A}, & 0 < t < 1 \\ 0.5 - 0.3746e^{-(t-1)} \text{ A}, & t > 1 \end{cases}$$

7.55 $1.667(1 - e^{-t})$ V

7.57 $0.4e^{-50t}$ mA, $t > 0$

7.59 $8(1 - e^{-4t})$ V, $t > 0$

7.61 $20(1 + 10t)$ mV

7.63 $0.5e^{-10t}$ mA, $t > 0$

7.65 $0.1(2e^{-10t} - 1)$ V

7.67 See Fig. E.12.

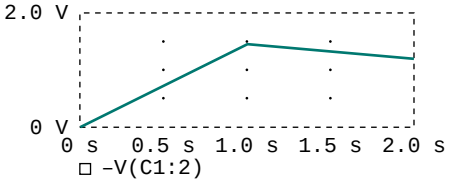


Figure E.12 For Prob. 7.67.

7.69 See Fig. E.13.

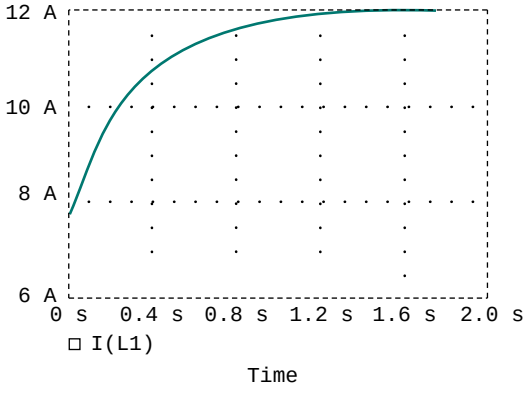


Figure E.13 For Prob. 7.69.

7.71 30 Ω

7.73 $0.2197 < t_0 < 2.197$

7.75 (a) 0.6 ms, (b) 6 μs

7.77 $\frac{2}{3}$ MΩ, 25 pF

7.79 See Fig. E.14.

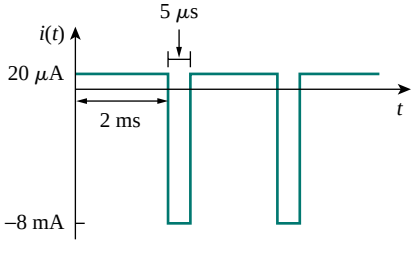


Figure E.14 For Prob. 7.79 (not to scale).

Chapter 8

8.1 (a) 2 A, 12 V, (b) −4 A/s, −5 V/s, (c) 0 A, 0 V

8.3 (a) 0 A, −10 V, 20 V, (b) 0 A/s, 0 V/s, 0 V/s, (c) 0.4 A, 6 V, 16 V

8.5 (a) 0 A, 0 V, (b) 0.25 A/s, 0 V/s, (c) 2.4 A, 9.6 V

8.7 $s^2 + 4s + 4 = 0$, $(1 + t)e^{-2t}$

8.9 $(10 + 50t)e^{-5t}$ A

8.11 $10(1 + t)e^{-t}$ V

8.13 120 Ω

8.15 750 Ω, 200 μF, 25 H

8.17 $24 \sin 0.5t$ V

8.19 $18e^{-t} - 2e^{-9t}$ V

8.21 40 mF

8.23 $(24 \cos 1.984t + 3.024 \sin 1.984t)e^{-t/4}$ V

8.25 $3 - 3(\cos 2t + \sin 2t)e^{-2t}$ V

8.27 (a) $3 - 3\cos 2t + \sin 2t$ V, (b) $2 - 4e^{-t} + 4e^{-4t}$ A,
(c) $3 + (2 + 3t)e^{-t}$ V, (d) $2 + 2\cos 2te^{-t}$ A

8.29 $50 - e^{-3t}(62 \cos 4t + 46.5 \sin 4t)$ V

8.31 $-10 \sin 8t$ A

8.33 $35 - (15 \cos 0.6t + 20 \sin 0.67t)e^{-0.8t}$ V, $5 \sin 0.6te^{-0.8t}$ A

8.35 $2.46e^{-0.903t} - 0.667e^{-4.3t}$ A

8.37 $(3 - 9t)e^{-5t}$ A

8.39 $-12 + (4 \cos 4t + 3 \sin 4t)e^{-3t}$ V

8.41 $6 - 6e^{-50t}(\cos 5000t + 0.01 \sin 5000t)$ mA

8.43 $-2(1 + t)e^{-2t}$ A, $(2 + 4t)e^{-2t}$ V

8.45 $9 + 2e^{-10t} - 8e^{-2.5t}$ A

8.47 $R_1C_1R_2C_2\dfrac{d^2v_o}{dt^2} + (R_1C_1 + R_2C_2 + R_1C_2)\dfrac{dv_o}{dt} = R_1C_1\dfrac{dv_s}{dt}$

8.49 $7.45 - 3.45e^{-7.25t}$ V, $t > 0$

8.51 (a) $s^2 + 20s + 36 = 0$, (b) $-\dfrac{3}{4}e^{-2t} - \dfrac{5}{4}e^{-18t}$ A, $6e^{-2t} + 10e^{-18t}$ V

8.53 $2.4 - 2.667e^{-2t} + 0.2667e^{-5t}$ A, $9.6 - 16e^{-2t} + 6.4e^{-5t}$ V

8.55 $\dfrac{d^2v_o}{dt^2} + \left(\dfrac{1}{R_2} + \dfrac{1}{R_1C_1}\right)\dfrac{dv_o}{dt} + \dfrac{v_o}{R_1R_2C_1C_2} = -\dfrac{1}{R_1C_2}\dfrac{dv_s}{dt}$

8.57 $\dfrac{d^2v_o}{dt^2} + \dfrac{v_o}{R^2C^2} = 0$, $2 \sin 10t$

8.59 $-te^{-t}u(t)$ V

8.61 See Fig. E.15.

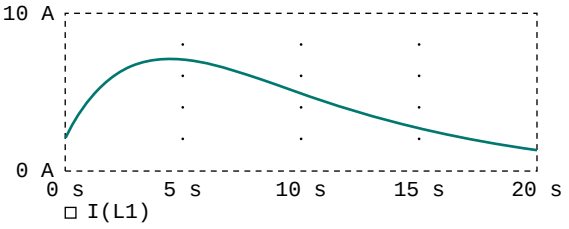


Figure E.15 For Prob. 8.61.

8.63 See Fig. E.16.

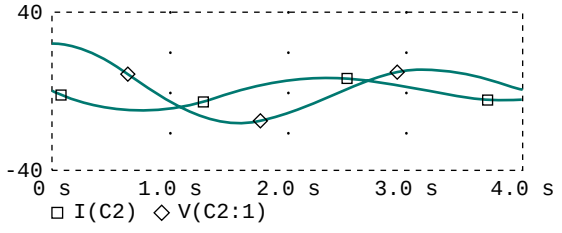


Figure E.16 For Prob. 8.63.

8.65 See Fig. E.17.

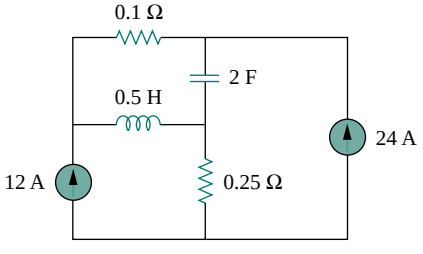


Figure E.17 For Prob. 8.65.

8.67 See Fig. E.18.

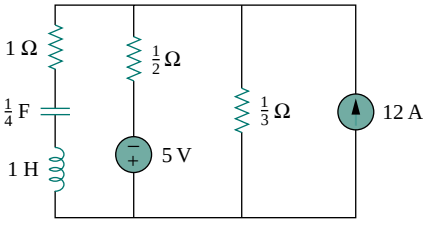


Figure E.18 For Prob. 8.67.

8.69 14.26-Ω resistor in parallel with a 176-μF capacitor

8.71 2.5 μM, 625 μF

8.73 $\dfrac{d^2v}{dt^2} + \dfrac{R}{L}\dfrac{dv}{dt} + \dfrac{R}{LC}i_D + \dfrac{1}{C}\dfrac{di_D}{dt} = \dfrac{v_s}{LC}$

Chapter 9

9.1 (a) 10^3 rad/s, (b) 159.2 Hz, (c) 6.283 ms, (d) $12\cos(10^3t - 66^\circ)$ V, (e) 2.65 V

9.3 (a) $4\cos(\omega t - 120^\circ)$, (b) $2\cos(6t + 90^\circ)$, (c) $10\cos(\omega t + 110^\circ)$

9.5 20°, v_1 lags v_2

9.7 Proof

9.9 (a) $1.809 + j0.4944$, (b) $4.201 - j1.392$, (c) $-0.5042 - j2.243$

9.11 (a) $118.3\angle -39.45^\circ$, (b) $10.45\angle -10.4^\circ$, (c) $1.849\angle -39.45^\circ$

9.13 (a) $10\angle -105^\circ$, (b) $5\angle -100^\circ$, (c) $5\angle -36.87^\circ$

9.15 (a) $60\cos(t + 15^\circ)$, (b) $10\cos(40t + 53.13^\circ)$, (c) $2.8\cos(377t - \pi/3)$, (d) $1.3\cos(10^3t + 247.4^\circ)$

9.17 (a) $40\cos(\omega t - 60^\circ)$, (b) $38.36\sin(\omega t + 96.8^\circ)$, (c) $6\cos(\omega t + 80^\circ)$, (d) $11.5\cos(\omega t - 52.06^\circ)$

9.19 (a) $0.8\cos(2t - 98.13^\circ)$, (b) $0.745\cos(2t - 4.56^\circ)$

9.21 $0.289\cos(377t - 92.45^\circ)$ V

9.23 $2\sin(10^6t - 65^\circ)$

9.25 6.5-Ω resistor

9.27 69.82 V

9.29 $-5\sin 2t$ V

9.31 (a) $4.472\cos(3t - 18.43^\circ)$ A, $17.89\cos(3t - 18.43^\circ)$ V, (b) $10\cos(4t + 36.87^\circ)$ A, $41.6\cos(4t + 33.69^\circ)$ V

9.33 (a) $1.872\cos(t - 22.05^\circ)$ A, (b) $0.89\cos(5t - 69.14^\circ)$ A, (c) $0.4417\cos(10t - 83.66^\circ)$ A

9.35 $17.14\cos 200t$ V

9.37 $0.96\cos(200t - 7.956^\circ)$ A

9.39 $2.325\cos(10t + 94.46^\circ)$ A

9.41 $25\cos(2t - 53.13^\circ)$ A

9.43 $8.485\angle 135^\circ$ A

9.45 (a) $0.75 + j0.25$ Ω, (b) $20 + j30$ Ω

9.47 $1 + j0.5$ Ω

9.49 $17.35\angle 0.9^\circ$ A, $6.83 + j1.094$ Ω

9.51 (a) $0.0148\angle -20.22^\circ$ S, (b) $0.0197\angle 74.57^\circ$ S

9.53 $1.661 + j0.6647$ S

9.55 $1.058 - j2.235$ Ω

9.57 $0.3796 + j1.46$ Ω

9.59 Can be achieved by the RL circuit shown in Fig. E.19.

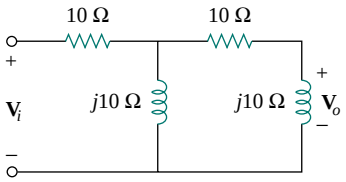


Figure E.19 For Prob. 9.59.

9.61 (a) 140.2°, (b) leading, (c) 18.43 V

9.63 1.8 kΩ, 0.1 μF

9.65 104.2 mH

9.67 Proof

9.69 $38.21\angle -8.975^\circ\ \Omega$

9.71 2 mH

9.73 235 pF

Chapter 10

10.1 $15.73\cos(t + 247.9^\circ)$ V

10.3 $3.835\cos(4t - 35.02^\circ)$ V

10.5 $6.154\cos(10^3 t + 70.26^\circ)$ V

10.7 $35.74\sin(1000t - 116.6^\circ)$ A

10.9 $7.906\angle 43.49^\circ$ A

10.11 $10.58\angle -112.4^\circ$ A

10.13 $16.64\angle 56.31^\circ$ V

10.15 (a) 1, 0, $-\dfrac{j}{R}\sqrt{\dfrac{L}{C}}$, (b) 0, 1, $\dfrac{j}{R}\sqrt{\dfrac{L}{C}}$

10.17 $\dfrac{\mathbf{V}_s(R + j\omega L + 1/j\omega C_2)}{(1/j\omega C_1 + 1/j\omega C_2)(R + j\omega L + 1/j\omega C_1) + 1/\omega^2 C_1 C_2}$,
$\dfrac{\mathbf{V}_s/j\omega C_2}{(1/j\omega C_1 + 1/j\omega C_2)(R + j\omega L + 1/j\omega C_1) + 1/\omega^2 C_1 C_2}$

10.19 $6.154\cos(10^3 t + 70.25^\circ)$ V

10.21 $4.67\angle -20.17^\circ$ A, $1.79\angle 37.35^\circ$ A

10.23 $2.179\angle 61.44^\circ$ A

10.25 $7.906\angle 43.49^\circ$ A

10.27 $1.971\angle -2.1^\circ$ A

10.29 $3.35\angle 174.3^\circ$ A

10.31 $9.902\cos(2t - 129.17^\circ)$ A

10.33 $10 + 21.45\sin(2t + 26.56^\circ) + 10.73\cos(3t - 26.56^\circ)$ V

10.35 $0.1 + 0.217\cos(2000t + 134.1^\circ) - 1.365\sin(4000t + 14.21^\circ)$ A

10.37 $3.615\cos(10^5 t - 40.6^\circ)$ V

10.39 $5.238\angle 17.35^\circ$ A

10.41 (a) $Z_N = Z_{\text{Th}} = 22.63\angle -63.43^\circ\ \Omega$, $\mathbf{V}_{\text{Th}} = -50\angle 30^\circ$ V, $\mathbf{I}_N = 2.236\angle 273.4^\circ$ A, (b) $Z_N = Z_{\text{Th}} = 10\angle 26^\circ\ \Omega$, $\mathbf{V}_{\text{Th}} = 33.92\angle 58^\circ$ V, $\mathbf{I}_N = 3.392\angle 32^\circ$ A

10.43 $Z_N = Z_{\text{Th}} = 21.633\angle -33.7^\circ\ \Omega$, $\mathbf{V}_{\text{Th}} = 107.3\angle 146.56^\circ$ V, $\mathbf{I}_N = 4.961\angle -179.7^\circ$ A

10.45 $15.73\cos(t + 247.9^\circ)$ V

10.47 $3.855\cos(4t - 35.02^\circ)$ V

10.49 1 kΩ, $5.657\cos(200t + 75^\circ)$ A

10.51 $0.542\cos(2t - 77.47^\circ)$ A

10.53 $-j\omega RC$, $-V_m\cos\omega t$

10.55 $35.76\cos(10^4 t - 26.56^\circ)\ \mu$A

10.57 $\dfrac{C_1}{C_2}\left(\dfrac{1 + j\omega R_2 C_2}{1 + j\omega R_1 C_1}\right)$, $\dfrac{C_1}{C_2}$, $\dfrac{R_2}{R_1}$, $\dfrac{C_1}{C_2}\left(\dfrac{1 + jR_2C_2/R_1C_1}{1 + j}\right)$, $\dfrac{C_1}{C_2}\left(\dfrac{1 + j}{1 + jR_1C_1/R_2C_2}\right)$

10.59 $\dfrac{R_2 + R_3 + j\omega C_2 R_2 R_3}{(1 + j\omega R_1 C_1)(R_3 + j\omega C_2 R_2 R_3)}$

10.61 $35.78\cos(1000t + 26.56^\circ)$ V

10.63 $1.465\angle 79.59^\circ$ A

10.65 $1.664\angle -146.4^\circ$ V

10.67 $15.91\angle 169.6^\circ$, $5.172\angle -138.6^\circ$, $2.27\angle -152.4^\circ$ V

10.69 Proof

10.71 (a) 180 kHz, (b) 40 kΩ

10.73 Proof

10.75 Proof

Chapter 11

11.1 $800 + 1600\cos(100t + 60^\circ)$, 800 W

11.3 7.5 W, 5 W, 0 W, 2.5 W, 0 W

11.5 12.48 W

11.7 43.78 W

11.9 0 W

11.11 (a) $0.471 + j1.882\ \Omega$, 15.99 W, (b) $2.5 - j1.167\ \Omega$, 1.389 W

11.13 $0.5 - j0.5\ \Omega$, 90 W

11.15 $21.23 - j10.15\ \Omega$

11.17 6.792 Ω, 6.569 W

11.19 9.574 V

11.21 7.906 V

11.23 2.92 V, 4.267 W

11.25 1.08 V

11.27 6.667 A

11.29 275.6 VA, 0.1876 (lagging)

11.31 (a) 0.5547 (leading), (b) 0.9304 (lagging)

11.33 (a) $95.26 - j55$ VA, 110 VA, 95.26 W, 55 VAR, leading pf
(b) $1497.2 + j401.2$ VA, 1550 VA, 1497.2 W, 401.2 VAR, lagging pf
(c) $278.2 + j74.54$ VA, 288 VA, 278.2 W, 74.54 VAR, lagging pf
(d) $-961.7 - j961.7$ VA, 1360 V, -961.7 W, -961.7 VAR, leading pf

11.35 (a) $269 - j150$ VA, (b) $4129 - j2000$ VA, (c) $396.9 + j450$ VA,
(d) $1000 + j681.2$ VA

11.37 (a) $30.98 - j23.23\ \Omega$, (b) $10.42 + j13.89\ \Omega$, (c) $0.8 + j1.386\ \Omega$

11.39 $-j3.84$ VA (capacitor), 5.12 VA (resistor), $j6.4$ VA (inductor)

11.41 $4.543 + j1.396$ VA

11.43 51.2 mVA

11.45 $7.098\angle 32.29^\circ$, 0.8454 (lagging)

11.47 $120.1\angle 0.03145^\circ$ V

11.49 80 μW

11.51 No power across the capacitors, $S_{10} = 4 \times 10^{-4}$, $S_{20} = 8 \times 10^{-4}$,
$S_{40} = 4 \times 10^{-4}$ VA

11.53 (a) 0.6402, (b) 295.1 W, (c) 130.4 μF

11.55 (a) 2.734 mF, (b) 6.3 mF

11.57 (a) 0.8992, (b) 5.74 mF

11.59 9.476 W

11.61 4.691 W

11.63 \$76.26

11.65 $75 - j103.55\ \Omega$

11.67 (a) 126.2 W, (b) 220 VA

11.69 968.2 kVAR

11.71 (a) 32.91 kVAR, 86.51 kVA, (b) 0.9248, (c) 157.3 A

11.73 (a) \$ 14,521.80, (b) \$ 31,579.2, (c) Yes

11.75 (a) $40 - j8\ \Omega$, (b) 66.61 W

Chapter 12

12.1 (a) $231\angle -30^\circ$, $231\angle -150^\circ$, $231\angle -270^\circ$ V,
(b) $231\angle 30^\circ$, $231\angle 150^\circ$, $231\angle -90^\circ$ V

12.3 *acb* sequence, $208\angle 250^\circ$ V

12.5 $242.5\angle -30^\circ$, $242.5\angle -150^\circ$, $242.5\angle 90^\circ$ V

12.7 $44\angle 53.13^\circ$, $44\angle -66.87^\circ$, $44\angle 173.1^\circ$ A

12.9 $4.8\angle -36.87^\circ$, $4.8\angle -156.9^\circ$, $4.8\angle 83.13^\circ$ A

12.11 $127\angle 100^\circ$ V, $220\angle 130^\circ$ V, $17.32\angle 150^\circ$ A, $12.7\angle -80^\circ$ Ω

12.13 13.66 A

12.15 $172.6\angle 34.76^\circ$, $172.6\angle -85.24^\circ$, $172.6\angle 154.8^\circ$ V, $11.51\angle -18.37^\circ$, $11.51\angle -138.4^\circ$, $11.51\angle 101.6^\circ$ A

12.17 $5.47\angle -18.43^\circ$, $5.47\angle -138.43^\circ$, $5.47\angle 101.57^\circ$ A, $9.474\angle -48.43^\circ$, $9.474\angle -168.43^\circ$, $9.474\angle 71.57^\circ$ A

12.19 $15.53\angle -28.4^\circ$, $15.53\angle -148.4^\circ$, $15.53\angle 91.6^\circ$ A

12.21 $17.74\angle 4.78^\circ$, $17.74\angle -115.2^\circ$, $17.74\angle 124.8^\circ$ A

12.23 $5.081\angle -46.87^\circ$, $5.081\angle -166.87^\circ$, $5.081\angle 73.13^\circ$ A

12.25 $4.15 - j5.53$ Ω, $5000 - j6667$ VA

12.27 7.69 A, 360.3 V

12.29 55.51 A, $1.298 - j1.731$ Ω

12.31 423.1 W

12.33 9.021 A

12.35 $4.373 - j1.145$ kVA

12.37 $6346\angle 28.92^\circ$ V

12.39 40.42 A (rms), 0.9677 (lagging)

12.41 $5.75\angle 220^\circ$ A

12.43 $3.464\angle 30^\circ$, $3.464\angle 0^\circ$, $3.464\angle 60^\circ$ A

12.45 (a) $132\angle 30^\circ$ A, $47.23\angle 143.8^\circ$ A, $120.9\angle 230.9^\circ$ A, (b) 29.04 kW, (c) $29.04 - j58.08$ kVA

12.47 $220.6\angle -34.56^\circ$, $214.1\angle -81.49^\circ$, $49.91\angle -50.59^\circ$ V, assuming that N is grounded.

12.49 $11.15\angle 37^\circ$ A, $230.8\angle -133.4^\circ$ V, assuming N is grounded.

12.51 $\mathbf{I}_{aA} = 4.71\angle 71.38^\circ$, $\mathbf{I}_{bB} = 6.781\angle -142.6^\circ$, $\mathbf{I}_{cC} = 3.898\angle -5.076^\circ$ V, $\mathbf{I}_{AB} = 3.547\angle 61.57^\circ$, $\mathbf{I}_{BC} = 3.831\angle -164.9^\circ$, $\mathbf{I}_{AC} = 1.357\angle 97.8^\circ$ V

12.53 (a) 120 V, (b) 2.5, 3, 2, 0.866 A, (c) 300, 360, 240 W, (d) 900 W

12.55 (a) 4801 VA, (b) 0.9372, (c) 8.4 A, (d) 190.5 V

12.57 (a) 2590 W, 4808 W, (b) 8335 VA

12.59 −2995 W, 2995 W

12.61 (a) 20 mA, (b) 200 mA

12.63 320 W

12.65 $17.15\angle -19.65^\circ$, $15.14\angle -139.6^\circ$, $15.14\angle 100.3^\circ$ A, $196.8\angle 2.97^\circ$, $196.8\angle -117^\circ$, $196.82\angle 123^\circ$ V

12.67 516 V

12.69 $\mathbf{Z}_Y = 2.133\ \Omega$

12.71 $1.448\angle -176.6^\circ$ A, $1252 + j711.6$ VA, $1085 + j721.2$ VA

Chapter 13

13.1 10 H

13.3 150 mH, 50 mH, 25 mH, 0.2887

13.5 $(R_1 + j\omega L_1)\mathbf{I}_1 - j\omega M\mathbf{I}_2$, $-j\omega M\mathbf{I}_1 + (R_2 + j\omega L_2)\mathbf{I}_2$

13.7 $2.392\angle 94.57^\circ$ V

13.9 $\dfrac{jI_m(\omega L - 1/\omega c)}{R + j\omega L + 1/j\omega C}$

13.11 $\mathbf{V}_{\text{Th}} = 5.349\angle 34.11^\circ$ V, $\mathbf{Z}_{\text{Th}} = 2.332\angle 50^\circ\ \Omega$

13.13 $2.462\angle 72.18^\circ$ A, $0.878\angle -97.48^\circ$ A, $3.329\angle 74.89^\circ$ A, 43.67 mJ

13.15 $3.199\angle -175.2^\circ$ A

13.17 (a) 0.3535, (b) $0.3217\cos(4t + 57.6^\circ)$ V, (c) 1.168 J

13.19 $3.755\angle -36.34^\circ$ A, $3.755\angle 143.7^\circ$ A

13.21 0.984, 130.5 mJ

13.23 (a) $L_a = 10$ H, $L_b = 15$ H, $L_c = 5$ H, (b) $L_A = 18.33$ H, $L_B = 27.5$ H, $L_C = 55$ H

13.25 $12.77 + j7.15\ \Omega$

13.27 $1.324\angle -53.05^\circ$ kΩ

13.29 0.5 A, -1.5 A

13.31 $\dfrac{V_m}{nR}\cos\omega t$ A, $-\dfrac{V_m}{n^2R}\cos\omega t$

13.33 $2.963\angle 32.9^\circ$ V, $2.963\angle -147.1^\circ$ V

13.35 $8 - j1.5\ \Omega$, $2.95\angle 10.62^\circ$ A

13.37 (a) 5, (b) 8 W

13.39 1054 W

13.41 (a) $25.9\angle 69.96^\circ$, $12.95\angle 69.96^\circ$ A (rms), (b) $21.06\angle 147.4^\circ$, $42.12\angle 147.4^\circ$, $42.12\angle 147.4^\circ$ V(rms), (c) $1554\angle 20.04^\circ$ VA

13.43 $P_{8\Omega} = 2.778$ W, $P_{2\Omega} = 11.11$ W, $P_{4\Omega} = 5.556$ W

13.45 6 A, 0.36 A, -60 V

13.47 $3.795\angle 18.43^\circ$, $1.897\angle 18.43^\circ$, $0.6325\angle 161.6^\circ$

13.49 $1.245\angle -33.76^\circ$, $0.8893\angle -33.76^\circ$, $0.3557\angle 146.2^\circ$ A, 7.51 W

13.51 74.9 W

13.53 (a) $\dfrac{1}{3}$, (b) 1604, 2778 A, (c) 2778, 4812 A

13.55 (a) delta-delta connection, (b) 66.67, 13.05 A, (c) 16.67, 28.87 A, (d) 55 kVA

13.57 (a) 144.3 A, (b) 238.7, (c) 13.05 A

13.59 $4.253\angle -8.526^\circ$ A, $1.564\angle 27.49^\circ$ A, 4.892 W

13.61 $1.304\angle 62.92^\circ$ A

13.63 $19.55\angle 83.32^\circ$ V, $68.47\angle 46.4^\circ$ V, $0.4434\angle -92.6^\circ$ A

13.65 $4.028\angle -52.38^\circ$, $2.019\angle -52.11^\circ$, $1.338\angle -52.2^\circ$ A

13.67 7.5 kΩ

13.69 315 W

13.71 (a) 0.1, (b) 25 turns, (c) 1.667 A, 16.67 A

13.73 (a) 112 V, (b) 0.2613 A, 11.2 A, (c) 1254 W

13.75 (a) 733.4 V, (b) 440 V

Chapter 14

14.1 $\dfrac{j\omega/\omega_o}{1+j\omega/\omega_o}, \omega_o = \dfrac{1}{RC}$

14.3 (a) $\dfrac{1}{s^2R^2C^2+3sRC+1}$, (b) $-4.787, -32.712$

14.5 (a) $\dfrac{1}{1+j\omega RC-\omega^2LC}$, (b) $\dfrac{j\omega L-\omega^2RLC}{R+j\omega L-\omega^2RLC}$

14.7 (a) 1.005773, (b) 0.4898, (c) 1.718×10^5

14.9 See Fig. E.20.

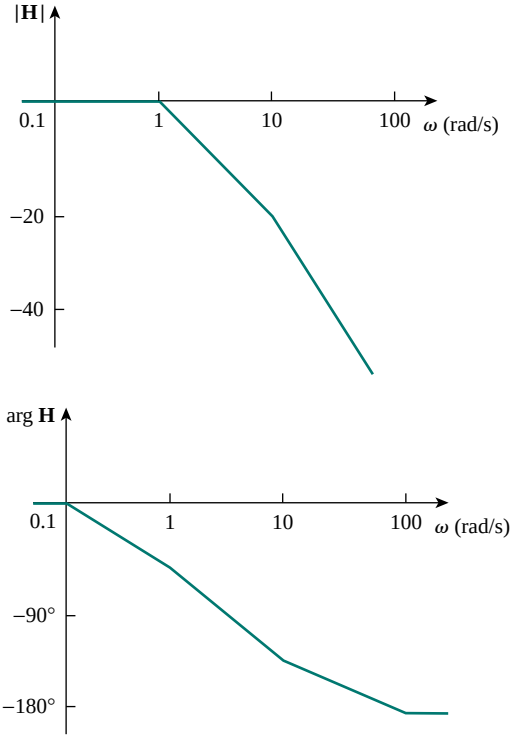


Figure E.20 For Prob. 14.9.

14.11 See Fig. E.21.

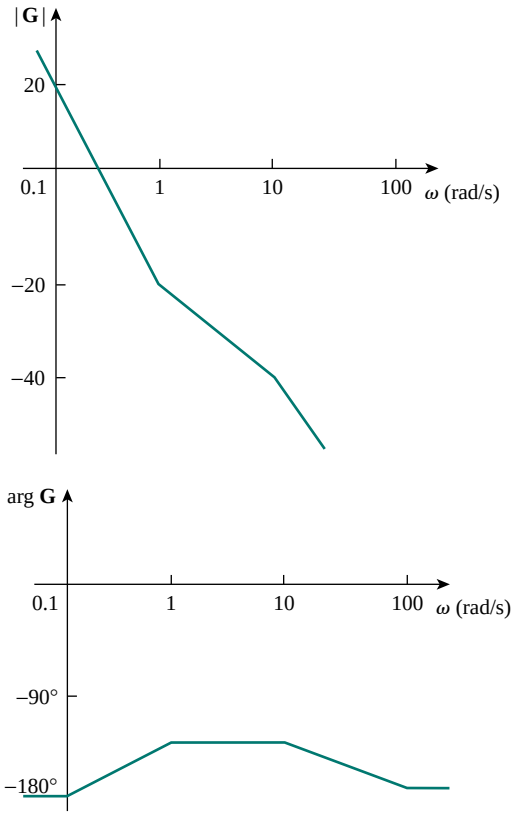


Figure E.21 For Prob. 14.11.

14.13 See Fig. E.22.

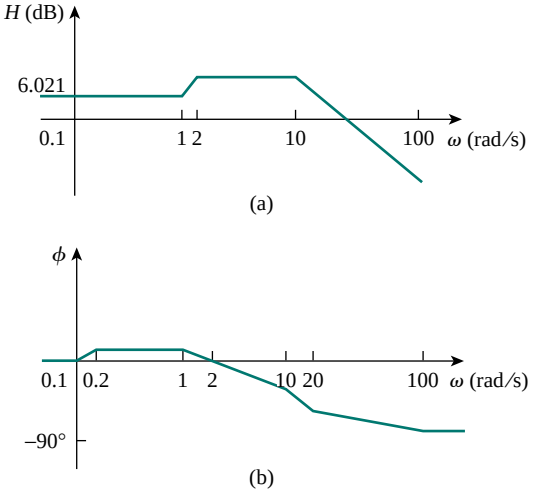


Figure E.22 For Prob. 14.13: (a) magnitude plot, (b) phase plot.

14.15 See Fig. E.23.

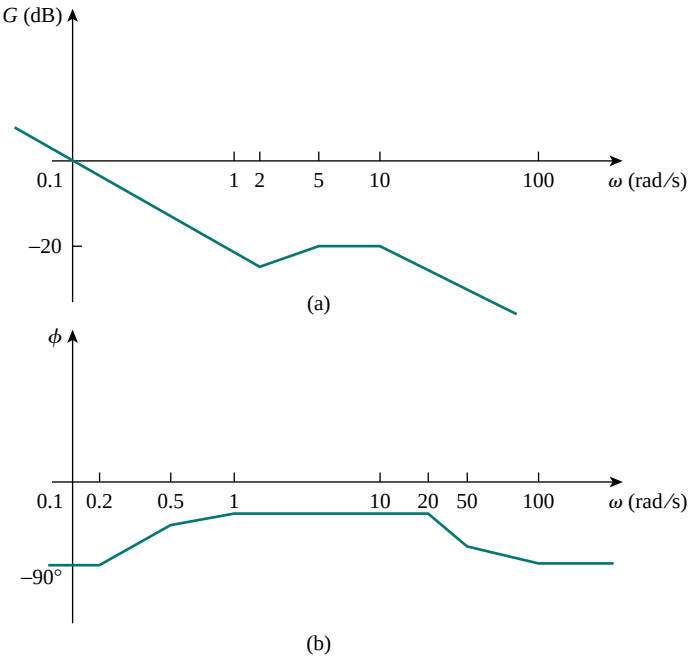


Figure E.23 For Prob. 14.15: (a) magnitude plot, (b) phase plot.

14.17 See Fig. E.24.

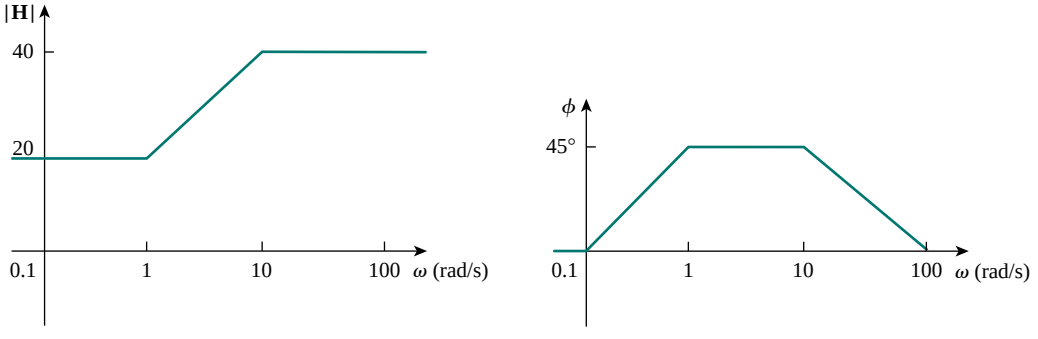


Figure E.24 For Prob. 14.17.

14.19 $\dfrac{10^4(2 + j\omega)}{(20 + j\omega)(100 + j\omega)}$

14.21 $\dfrac{Kj\omega}{(1 + j\omega)(100 + j\omega)}$, K = constant

14.23 $R = 10\ \Omega$, $L = 16$ H, $C = 25\ \mu$F, 0.625 rad/s

14.25 0.7861 rad/s

14.27 50 rad/s, 5.975×10^6 rad/s, 6.025×10^6 rad/s

14.29 2 kΩ, $0.6154 + j0.923$ kΩ, $1.471 + j0.8824$ kΩ, $1.471 - j0.8824$ kΩ, $0.6154 - j0.923$ kΩ

14.31 (a) 5 rad/s, 0.625, 8 rad/s, (b) 5 krad/s, 20, 250 rad/s

14.33 (a) 3.333 krad/s, (b) $0.9997 \angle 1.205^\circ$ Ω

14.35 (a) $\dfrac{j\omega}{2(1 + j\omega)^2}$, (b) 0.25

14.37 $\dfrac{R}{R + j\omega L - \omega^2 RLC}$, Proof

14.39 Highpass filter, 318.3 Hz

14.41 31.42 kΩ

14.43 1.56 kHz $< f <$ 1.59 kHz, 25

14.45 (a) 1 rad/s, 3 rad/s, (b) 1 rad/s, 3 rad/s

14.47 9.6 krad/s, 5 krad/s

14.49 (a) 23.53 mV, (b) 107.3 mV, (c) 119.4 mV

14.51 $\left(1 + \dfrac{R_f}{R_i}\right)$, $\dfrac{1}{RC}$

14.53 If $R_f = 20$ kΩ, then $R_i = 80$ kΩ and $C = 31.83$ nF.

14.55 Let $R = 10$ kΩ, then $R_f = 25$ kΩ, $C = 7.96$ nF.

14.57 $K_f = 2 \times 10^{-4}$, $K_m = 5 \times 10^{-3}$

14.59 9.6 MΩ, 32 μH, 0.375 pF

14.61 See Fig. E.25.

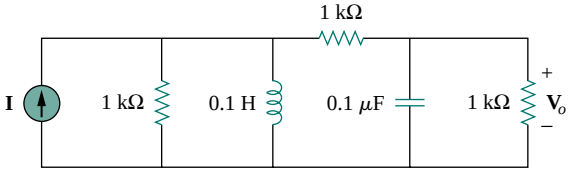


Figure E.25 For Prob. 14.61.

14.63 (a) See Fig. E.26, (b) $894.4 \angle 26.7^\circ$ Ω

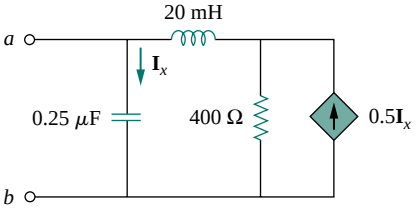
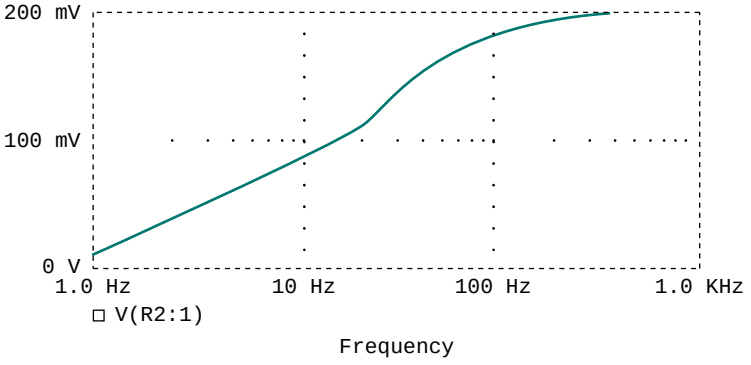
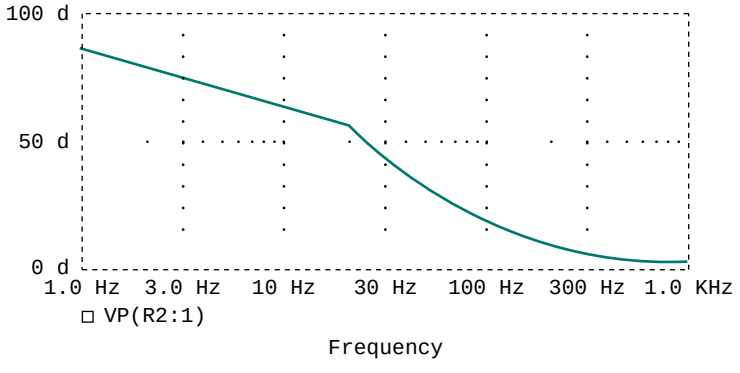


Figure E.26 For Prob. 14.63.

14.65 See Fig. E.27.



(a)



(b)

Figure E.27 For Prob. 14.65.

14.67 See Fig. E.28; high pass filter, $f_0 = 1.2$ Hz.

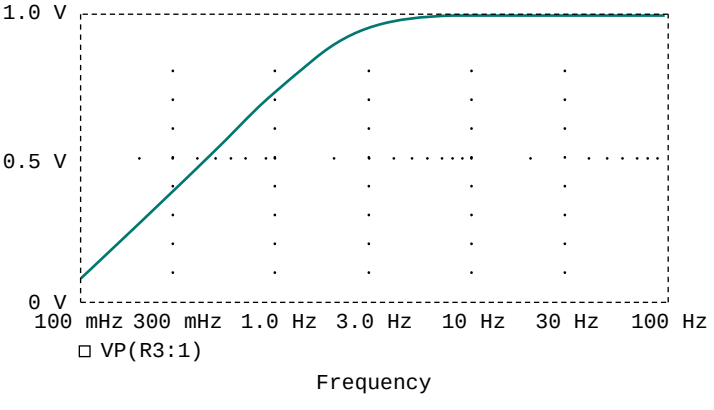


Figure E.28 For Prob. 14.67.

14.69 See Fig. E.29.

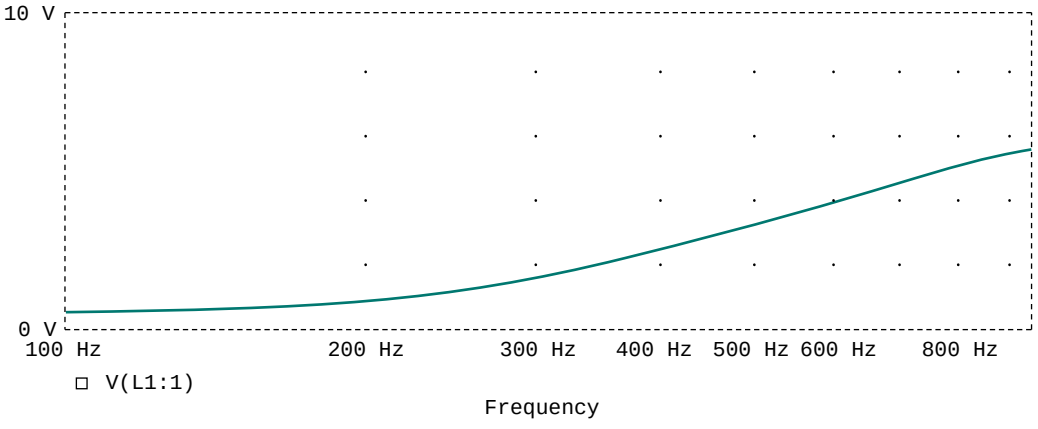


Figure E.29 For Prob. 14.69.

14.71 See Fig. E.30; $f_o = 800$ Hz.

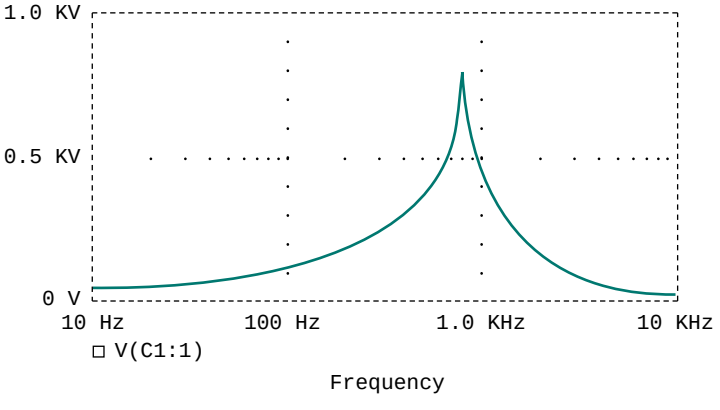


Figure E.30 For Prob. 14.71.

14.73 938 kHz, remains the same

14.75 $$\frac{R_L(R_L + sL + s^2R_LLC_2)}{(R_L + sL + s^2R_LC_2L)(sL + R_L + s^2R_LLC_2 + R_i + sR_iR_LC_2 + s^3R_iR_LC_2 + sR_iR_LC_1 + s^3R_iR_LLC_1C_2)}$$

14.77 440 Hz

14.79 15.91 Ω

14.81 (a) 2 kHz, (b) 1.59 kHz

14.83 See Fig. E.31.

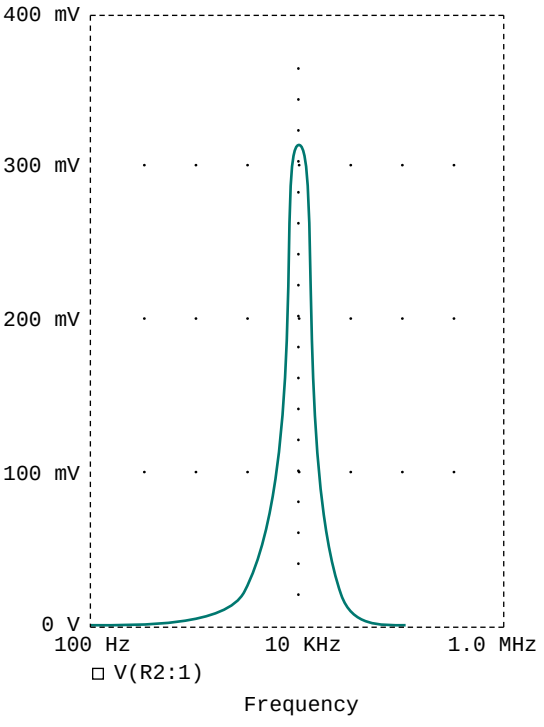


Figure E.31 For Prob. 14.83.

Chapter 15

15.1 (a) $\frac{s}{s^2 - a^2}$, (b) $\frac{a}{s^2 - a^2}$

15.3 (a) $\frac{s+2}{(s+2)^2 + 9}$, (b) $\frac{4}{(s+2)^2 + 16}$, (c) $\frac{s+3}{(s+3)^2 - 4}$ (d) $\frac{1}{(s+4)^2 - 1}$, (e) $\frac{4(s+1)}{[(s+1)^2 - 4]^4}$

15.5 (a) $2e^{-s}$, (b) $\frac{10}{s}e^{-2s}$, (c) $\frac{1}{s^2} + \frac{1}{s}$, (d) $\frac{2e^{-4s}}{e^4(s+1)}$

15.7 (a) $\frac{3}{2} + \frac{6}{s} + \frac{4}{s+2} - \frac{10}{s+3}$, (b) $\frac{e^{-(s+1)}}{(s+1)^2} + \frac{e^{-(s+1)}}{s+1}$, (c) $\frac{se^{-s}}{s^2+4}$, (d) $\frac{4}{s^2+16}(1 - e^{-\pi s})$

15.9 (a) $-\frac{(s+2)}{s^2 + 2s + 2}$, (b) $\frac{-(s+2)}{s^2 + 2s + 2}$

15.11 $\frac{5}{s^2}(1 - 2e^{-s} + e^{-2s})$

15.13 $\frac{1}{s}(5 - 3e^{-s} + 3e^{-3s} - 5e^{-4s})$

15.15 (a) $\frac{1}{s}(1+e^{-s}+e^{-2s}-3e^{-3s})$, (b) $\frac{2}{s^2}(1-e^{-s}-e^{-3s}+e^{-4s})$

15.17 $\frac{\pi(1+e^{-s})}{(s^2+\pi^2)(1-e^{-2s})}$

15.19 (a) $\frac{2(1-e^{-s}+se^{-s})}{s^2(1-e^{-s})}$, (b) $\frac{1}{s}+\frac{2}{s^2}\frac{(1-e^{-s})^2}{(1-e^{-2s})}$

15.21 (a) ∞, 0, (b) $f(0)=1$, $f(\infty)$ does not exist, (c) 0, 0

15.23 (a) 1, 0, (b) $f(0)=1$, $f(\infty)$ does not exist

15.25 (a) $-5e^{-t}+20e^{-2t}-15e^{-3t}$ (b) $-e^{-t}+\left(1+3t-\frac{t^2}{2}\right)e^{-2t}$,
(c) $e^{-t}(-0.2+0.2\cos 2t+0.4\sin 2t)$

15.27 (a) $3\sin t-\cos t+3e^{-t}$, (b) $\cos(t-\pi)u(t-\pi)$,
(c) $8u(t)[1-e^{-t}-te^{-t}-0.5t^2e^{-t}]$

15.29 (a) $[2e^{-(t-6)}-e^{-2(t-6)}]u(t-6)$,

(b) $\frac{4}{3}u(t)[e^{-t}-e^{-4t}]-\frac{1}{3}u(t-2)[e^{-(t-2)}-e^{-4(t-2)}]$,

(c) $\frac{1}{13}u(t)[-3e^{-3(t-1)}+3\cos 2(t-1)+2\sin 2(t-1)]$

15.31 (a) $3[1-\cos 2(t-2)]u(t-2)$,

(b) $\frac{1}{4}\cos t+\frac{1}{8}\sin t-\frac{1}{4}\cos 3t-\frac{1}{24}\sin 3t$,

(c) $4e^{-2t}(-1+t+\cos 3t-5\sin 3t)$

15.33 (a) $-3.138e^{-t}\cos 4t-2.358e^{-t}\sin 4t+5.138e^{-2t}\cos 4t+1.142e^{-2t}\sin 4t$,

(b) $\left[\frac{1}{4}\cos 3t+\frac{1}{12}\sin 4t-\frac{1}{8}e^{-0.551t}+\frac{1}{8}e^{-5.449t}\right]u(t)$

15.35 $2e^{-t}-2e^{-3t}\cos t-4e^{-3t}\sin t$ V

15.37 $(0.5+2.887e^{-t}\sin 1.732t)u(t)$ A, $-1.732e^{-t}\sin 1.732t\,u(t)$ A

15.39 $[2e^{-2t}-e^{-t}]u(t)$ A

15.41 $0.7143e^{-2t}-1.714e^{-0.5t}\cos 1.118t+2.3e^{-0.5t}\sin 1.118t$ A

15.43 $-(2+4.333e^{-t/2}+1.333e^{-2t})u(t)$ V

15.45 $(5e^{-4t}\cos 2t+230e^{-4t}\sin 2t)u(t)$ V,
$6u(t)-6e^{-4t}\cos 2t-11.37e^{-4t}\sin 2t$ A, $t>0$

15.47 $(e^{-5t}-e^{-2t})u(t)$

15.49 $2.91(e^{-4.581t}-e^{-0.438t})u(t)$

15.51 $12u(t)$

15.53 (a) $[0.6-0.6e^{-2t}\cos t-0.2e^{-2t}\sin t]u(t)$,
(b) $[6e^{-2t}+6te^{-2t}-6e^{-2t}\cos t-6e^{-2t}\sin t]u(t)$

15.55 $\frac{20}{2s^2+9s+30}$

15.57 9

15.59 (a) $\frac{1}{s^3+2s^2+3s+2}$, (b) $\frac{1}{s^3+s^2+2s+2}$, (c) $\frac{1}{s^3+s^2+3s+2}$,

(d) $\frac{1}{s^3+2s^2+3s+2}$

15.61 (a) $\frac{R}{L}e^{-Rt/L}u(t)$, (b) $(1-e^{-Rt/L})u(t)$

15.63 $0.5e^{-t/2}u(t)$

15.65 (a) $y(t)=\begin{cases}\frac{1}{2}t^2, & 0<t<1\\ -\frac{1}{2}t^2+2t-1, & 1<t<2\\ 1, & t>2\\ 0, & \text{otherwise}\end{cases}$

(b) $y(t)=2(1-e^{-t}),\ t>0,$

(c) $y(t)=\begin{cases}\frac{1}{2}t^2+t+\frac{1}{2}, & -1<t<0\\ \frac{1}{2}t^2-3t+\frac{9}{2}, & 2<t<3\\ 0, & \text{otherwise}\end{cases}$

15.67 Proof

15.69 $\frac{1}{2}t\cos t+\frac{1}{2}\sin t$

15.71 $\frac{9}{26}\cos 2t+\frac{6}{26}\sin 2t+\frac{17}{26}e^{-t}\cos 3t-\frac{47}{78}e^{-t}\sin 2t$

15.73 $\frac{27}{4}e^{-2t}-\frac{75}{13}e^{-3t}+\frac{1}{52}\cos 2t+\frac{5}{52}\sin 2t$

15.75 $\left[\frac{1}{10}e^{-2t}-\frac{1}{26}e^{-4t}-\frac{4}{65}e^{-t}\cos 2t-\frac{1}{130}e^{-t}\sin 2t\right]u(t)$

15.77 $-0.4\sin 2t+\cos 3t+0.6\sin 3t$

15.79 $-6.235e^{-t}+7.329e^{-1.5t}-0.0935\cos 4t-0.06445\sin 4t$

15.81 (a) $(e^{-t}-e^{-4t})u(t)$, (b) stable

15.83 $L=0.333$ H, $C=0.5$ F

15.85 $C_1=C_2=100\ \mu$F

15.87 $a=-100,\ b=400,\ c=20{,}000$

15.89 Proof

Chapter 16

16.1 (a) periodic, 2, (b) not periodic, (c) periodic, 2, (d) periodic, π, (e) periodic, 10, (f) not periodic, (g) not periodic

16.3 $a_0=3,75,\ a_n=\begin{cases}-\frac{5}{n\pi}(-1)^{n-1/2}, & n=\text{odd}\\ 0, & n=\text{even}\end{cases},$

$b_n=\frac{5}{n\pi}\left[3-2\cos n\pi-\cos\frac{n\pi}{2}\right]$

16.5 $\frac{2\pi^2}{3}-\sum_{n=1}^{\infty}\frac{4}{n^2}\cos nt$

16.7 $2+\sum_{n=1}^{\infty}\left[\frac{10}{n^3+1}\cos\frac{n\pi}{4}\cos n\pi t-\frac{10}{n^3+1}\sin\frac{n\pi}{4}\sin 2nt\right]$

16.9 $\dfrac{8}{\pi^2}\left[\sin\dfrac{\pi t}{2} - \dfrac{1}{9}\sin\dfrac{3\pi t}{2} + \dfrac{1}{25}\sin\dfrac{5\pi t}{2} + \cdots\right]$

16.11 (a) π, odd, (b) $2\pi/3$, even, (c) $\pi/2$, even and half-wave symmetric

16.13 $2 + \dfrac{24}{\pi^2}\sum_{n=1}^{\infty}\dfrac{1}{n^2}\left(\cos\dfrac{2n\pi}{3} - \cos\dfrac{n\pi}{3}\right)\cos\dfrac{n\pi t}{3}$, 3.756

16.15 $a_0 = 1,\ b_n = 0,\ a_n = \dfrac{16}{n^2\pi^2}\left(\cos\dfrac{n\pi}{2} - 1\right) + \dfrac{8}{n\pi}\sin\dfrac{n\pi}{2}$

16.17 (a) $a_2 = 0,\ b_2 = -0.3183$, (b) $0.06366\angle -90^\circ$, (c) 1.384, which is 8% off the exact value of 1.5, (d) Proof

16.19 $1 + \sum_{n=1}^{\infty}\dfrac{4}{n\pi}\left[\left(\sin\dfrac{3n\pi}{2} - \sin\dfrac{n\pi}{2}\right)\cos\dfrac{n\pi t}{2} + (\cos n\pi - 1)\sin\dfrac{n\pi t}{2}\right]$

16.21 $\sum_{k=1}^{\infty}\left[\dfrac{8}{n^2\pi^2}\cos n\pi t + \dfrac{4}{n\pi}\sin n\pi t\right],\ n = 2k-1$

16.23 $\dfrac{1}{3} + \sum_{n=1}^{\infty}\dfrac{1}{3n^2\sqrt{1+4n^2}}\cos(3n - \tan^{-1}2n)$ A

16.25 $\dfrac{3}{8} + \sum_{n=\text{odd}}^{\infty} A_n\cos\left(\dfrac{2\pi n}{3} + \theta_n\right)$, where

$$A_n = \frac{\dfrac{6}{n\pi}\sin\dfrac{2n\pi}{3}}{\sqrt{9\pi^2n^2 + (2\pi^2n^2/3 - 3)^2}},\ \theta_n = \frac{\pi}{2} - \tan^{-1}\left(\frac{2n\pi}{9} - \frac{1}{n\pi}\right)$$

16.27 $\dfrac{100}{\pi}\sum_{k=1}^{\infty}\dfrac{\sin(n\pi t - 90^\circ + \tan^{-1}5/n\pi)}{n\sqrt{25+n^2\pi^2}},\ n = 2k-1$ V

16.29 $\dfrac{3}{4} + \sum_{n=1}^{\infty} V_n\cos(n\pi t + \theta_n)$ V, where

$$V_n = \frac{12}{\sqrt{64+n^2\pi^2}}\sqrt{\frac{4}{n^2\pi^2} + \frac{16}{\pi^4(2n-1)^4}},$$

$$\theta_n = \tan^{-1}\frac{n\pi}{8} - \tan^{-1}\frac{\pi(2n-1)^2}{2n}$$

16.31 (a) 33.91 V, (b) 6.782 A, (c) 203.1 W

16.33 (a) 1.155, (b) 0.8162

16.35 (a) $40 + 0.01431\cos(10t - 18.43^\circ) + 0.05821\cos(20t - 136^\circ)$ V, (b) 800 mW

16.37 (a) $\dfrac{\pi^2}{3} + \sum_{n=-\infty,n\neq0}^{\infty}\dfrac{2(-1)^n}{n^2}e^{jnt}$

16.39 $\sum_{n=-\infty}^{\infty}\dfrac{0.6321e^{j2n\pi t}}{1 + j2n\pi}$

16.41 $\sum_{n=-\infty}^{\infty}\dfrac{1 + e^{-jn\pi}}{2\pi(1-n^2)}e^{jnt}$

16.43 $-3 + \sum_{n=-\infty,n\neq0}^{\infty}\dfrac{3}{n^3 - 2}e^{j50nt}$

16.45 $\frac{1}{2} - \sum_{n=-\infty, n\neq 0}^{\infty} \frac{j5e^{j(2n+1)\pi t}}{(2n+1)\pi}$

16.47 (a) $6 + 2.571\cos t - 3.83\sin t + 1.638\cos 2t - 1.147\sin 2t + 0.906\cos 3t - 0.423\sin 3t + 0.47\cos 4t - 0.171\sin 4t$, (b) 6.828

16.49 See Fig. E.32.

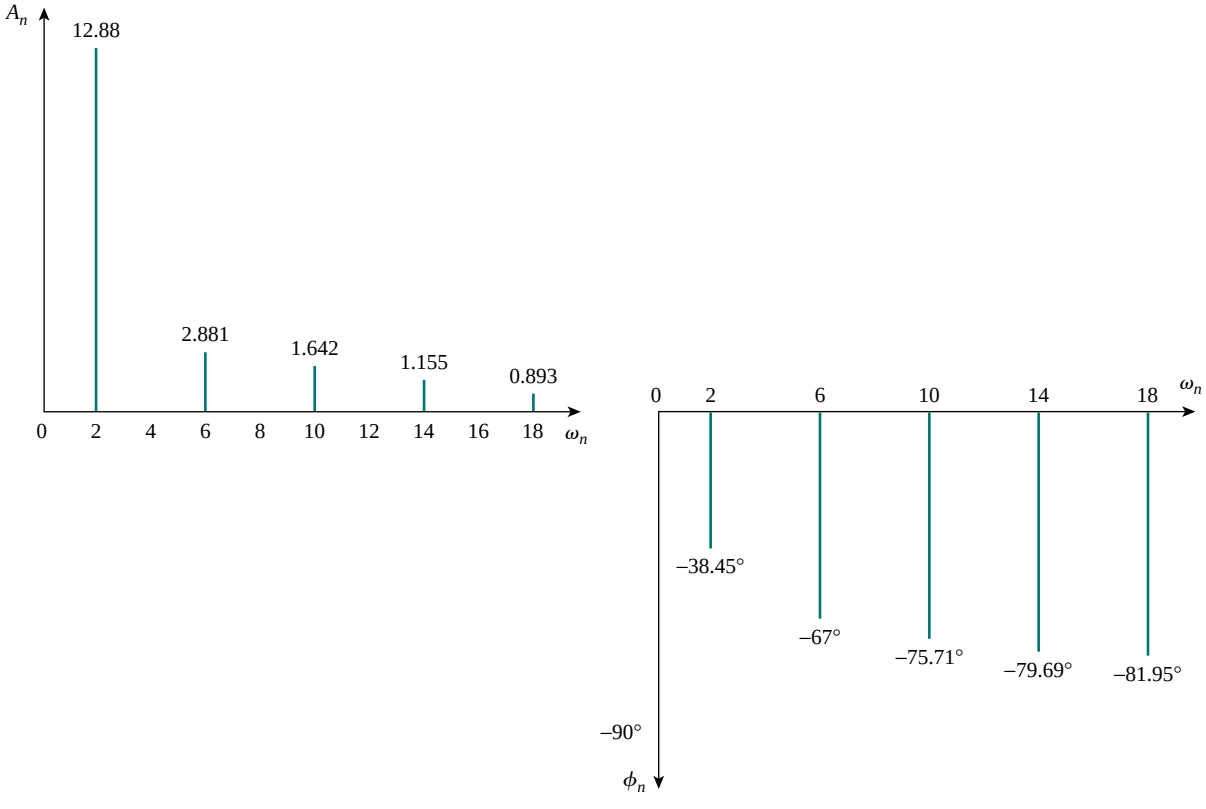


Figure E.32 For Prob. 16.49.

16.51 DC COMPONENT = 4.950000E-01

HARMONIC NO	FREQUENCY (HZ)	FOURIER COMPONENT	NORMALIZED COMPONENT	PHASE (DEG)	NORMALIZED PHASE (DEG)
1	1.667E-01	2.432E+00	1.000E+00	-8.996E+01	0.000E+00
2	3.334E-01	6.576E-04	2.705E-04	-8.932E+01	6.467E-01
3	5.001E-01	5.403E-01	2.222E-01	9.011E+01	1.801E+02
4	6.668E+00	3.343E-04	1.375E-04	9.134E+01	1.813E+02
5	8.335E-01	9.716E-02	3.996E-02	-8.982E+01	1.433E-01
6	1.000E+00	7.481E-06	3.076E-06	-9.000E+01	-3.581E-02
7	1.167E+00	4.968E-02	2.043E-01	-8.975E+01	2.173E-01
8	1.334E+00	1.613E-04	6.634E-05	-8.722E+01	2.748E+00
9	1.500E+00	6.002E-02	2.468E-02	-9.032E+01	1.803E+02

16.53

```
DC COMPONENT = 7.658051E-01

HARMONIC   FREQUENCY    FOURIER    NORMALIZED     PHASE      NORMALIZED
   NO        (HZ)      COMPONENT   COMPONENT      (DEG)      PHASE (DEG)

   1       5.000E-01  1.070E+00  1.000E+00   1.004E+01   0.000E+00
   2       1.000E+00  3.758E-01  3.512E-01  -3.924E+01  -4.928E+01
   3       1.500E+00  2.111E-01  1.973E-01  -3.985E+01  -4.990E+01
   4       2.000E+00  1.247E-01  1.166E-01  -5.870E+01  -6.874E+01
   5       2.500E+00  8.538E-02  7.980E-02  -5.680E+01  -6.685E+01
   6       3.000E+00  6.139E-02  5.738E-02  -6.563E+01  -7.567E+01
   7       3.500E+00  4.743E-02  4.433E-02  -6.520E+01  -7.524E+01
   8       4.000E+00  3.711E-02  3.469E-02  -7.222E+01  -8.226E+01
   9       4.500E+00  2.997E-02  2.802E-02  -7.088E+01  -8.092E+01
```

16.55 $\dfrac{20}{\pi}\displaystyle\sum_{n=1}^{\infty}\frac{1}{n}\left(1-\cos\frac{2n\pi}{5}\right)\sin\frac{2n\pi t}{5}$

16.57 (a) $4+10\cos(100\pi t-36.87^\circ)-5\cos(200\pi t-36.87^\circ)$ A, (b) 157 W

16.59 (a) π, (b) 2 V, (c) 11.02 V

16.61 See below for the program in Fortran and the results.

```
C FOR PROBLEM 16.16
      DIMENSION B(20)

      A = 10
      PIE = 3.142
      C = 4.*A/PIE
      DO 10 N=1, 10
      B(N) = C/(2.*FLOAT(N) - 1.)
      PRINTS *, N, B(N)
10    CONTINUE
      STOP
      END
```

n	b_n
1	12.7307
2	4.2430
3	2.5461
4	1.8187
5	1.414
6	1.1573
7	0.9793
8	0.8487
9	0.7488
10	0.6700

16.63 (a) $\dfrac{A^2}{2}$, (b) $c_1=\dfrac{8A^2}{9\pi^2}$, $c_2=\dfrac{2A^2}{225\pi^2}$, $c_3=\dfrac{8A^2}{1225\pi^2}$, $c_4=\dfrac{8A^2}{3969\pi^2}$,

(c) 81.1%, (d) 0.72%

Chapter 17

17.1 $\dfrac{2(\cos 2\omega - \cos \omega)}{j\omega}$

17.3 $\dfrac{j}{\omega^2}(\sin 2\omega - 2\omega \cos 2\omega)$

17.5 (a) $\dfrac{1}{j\omega}(2 - e^{-j\omega} - e^{-j2\omega})$, (b) $\dfrac{2}{\omega^2}[e^{-j\omega} + j\omega e^{-j\omega 2} - 1]$

17.7 $\dfrac{\pi}{\omega^2 - \pi^2}(e^{-j\omega 2} - 1)$

17.9 (a) $\dfrac{-(1 + j\omega)}{(1 + j\omega)^2 + 9}$, (b) $\dfrac{2j\pi \sin \omega}{\pi^2 - \omega^2}$, (c) $\dfrac{-(2 + j\omega)e^{j\omega - 2}}{(2 + j\omega)^2 + \pi^2}$,
(d) $\dfrac{j\omega - 2}{(\omega - 2)^2 + 16}$, (e) $\dfrac{6}{j\omega}e^{-j\omega 2} + 3 - 2\pi\delta(\omega)e^{-j\omega 2}$

17.11 (a) $-4\pi|\omega|$, (b) $4\pi e^{-2|\omega|}$

17.13 $\dfrac{1 + j\omega}{2 + j2\omega - \omega^2}$

17.15 (a) Proof, (b) $\dfrac{1}{2}\delta(\omega) - \displaystyle\sum_{\substack{n=-\infty \\ n \neq 0 \\ n = \text{odd}}}^{\infty} \dfrac{j}{n\pi}\delta(\omega - n)$

17.17 (a) $\dfrac{30}{(6 - j\omega)(15 - j\omega)}$, (b) $\dfrac{20e^{-j\omega/2}}{(4 + j\omega)(10 + j\omega)}$,
(c) $\dfrac{5}{[2 + j(\omega + 2)][5 + j(\omega + 2)]} + \dfrac{5}{[2 + j(\omega - 2)][5 + j(\omega - 2)]}$,
(d) $\dfrac{j\omega 10}{(2 + j\omega)(5 + j\omega)}$, (e) $\dfrac{10}{j\omega(2 + j\omega)(5 + j\omega)} + \pi\delta(\omega)$

17.19 (a) $\dfrac{5}{2}\text{sgn}(t) - 5e^{-2t}u(t)$, (b) $(-5e^{-t} + 6e^{-2t})u(t)$

17.21 (a) 0.05, (b) $\dfrac{(-2 + j)}{2\pi}e^{-j2t}$, (c) $\dfrac{(1 - j)}{\pi}e^{jt}$, (d) $u(t) - e^{-5t}$

17.23 (a) $e^{(t+1)}u(-t - 1)$, (b) $\dfrac{2}{\pi(t^2 + 1)}$,
(c) $\dfrac{1}{4}(t + 1)e^{-t}u(t) + \dfrac{1}{4}(t - 1)e^{t}u(t)$, (d) $\dfrac{1}{2\pi}$

17.25 $\dfrac{20}{\pi}\,\text{sinc}\,2t + \dfrac{10}{\pi}\,\text{sinc}\,t$

17.27 $\dfrac{j\omega}{4 + j3\omega}$

17.29 $\dfrac{1}{2}[\text{sgn}(t) + \text{sgn}(t - 2) - 2\,\text{sgn}(t - 1)] - e^{-0.5t}u(t)$
$-e^{-0.5(t-2)}u(t - 2) - 2e^{-0.5(t-1)}u(t - 1)$

17.31 $4\delta(t) - 8e^{-2t}u(t)$ A

17.33 $-3e^{-2t} + 1.875e^{2t}u(-t) - 1.125e^{-6t}\cos 8tu(t)$
$+ 0.375e^{-6t}\sin 8tu(t)$ V

17.35 $\dfrac{8(2 + j\omega)}{2 + j\omega 5 - 3\omega^2}$

17.37 $0.542\cos(t + 13.64°)$ V

17.39 $\dfrac{1}{6}$

17.41 8 J

17.43 0.15 J

17.45 (a) 5 kHz, (b) 4.9 kHz, (c) 5.1 kHz

17.47 $6.5 < f < 9.6$ kHz, $10.4 < f < 13.5$ kHz

17.49 100 stations

17.51 111 ns

17.53 21.37%

Chapter 18

18.1 $\begin{bmatrix} 4 & 1 \\ 1 & 1.667 \end{bmatrix}\ \Omega$

18.3 (a) $\begin{bmatrix} 1 + j & j \\ j & 0 \end{bmatrix}\ \Omega$, (b) $\begin{bmatrix} 1.5 + j0.5 & 1.5 - j0.5 \\ 1.5 - j0.5 & 1.5 - j1.5 \end{bmatrix}\ \Omega$

18.5 $\begin{bmatrix} \dfrac{s^2 + s + 1}{s^3 + 2s^2 + 3s + 1} & \dfrac{1}{s^3 + 2s^2 + 3s + 1} \\ \dfrac{1}{s^3 + 2s^2 + 3s + 1} & \dfrac{s^2 + 2s + 2}{s^3 + 2s^2 + 3s + 1} \end{bmatrix}\ \Omega$

18.7 $\begin{bmatrix} 1.6667 & 0.2222 \\ -0.6667 & 1.111 \end{bmatrix}\ \Omega$

18.9 See Fig. E.33.

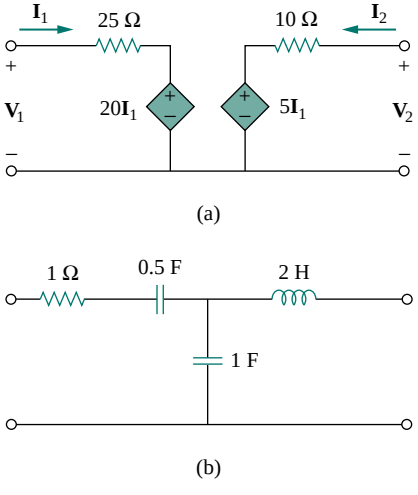


Figure E.33 For Prob. 18.9.

18.11 5.877 kW

18.13 $\mathbf{Z}_{\text{Th}} = 6.4\ \Omega$, $\mathbf{V}_{\text{Th}} = 6\angle 90^\circ$ V, $3.18\cos(2t + 148^\circ)$ V

18.15 $\begin{bmatrix} \frac{1}{8} & -\frac{1}{12} \\ -\frac{1}{12} & \frac{1}{2} \end{bmatrix}$ S

18.17 See Fig. E.34.

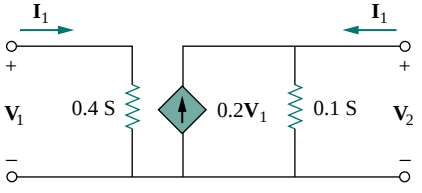


Figure E.34 For Prob. 18.17.

18.19 See Fig. E.35.

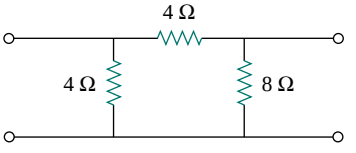


Figure E.35 For Prob. 18.19.

18.21 $\begin{bmatrix} 0.25 & 0.25 \\ 5 & 0.6 \end{bmatrix}\ \Omega$

18.23 (a) 8 V, 22 V, (b) same

18.25 $\begin{bmatrix} 3.8\ \Omega & 0.4 \\ -3.6 & 0.2\ \text{S} \end{bmatrix}$

18.27 $\begin{bmatrix} 85\ \Omega & 0.25 \\ 14.75 & 0.0725\ \text{S} \end{bmatrix}, \begin{bmatrix} 0.02929\ \text{S} & -0.101 \\ -5.96 & 34.34\ \Omega \end{bmatrix}$

18.29 (a) 0.2941, (b) -1.6, (c) 7.353×10^{-3} S, (d) 40 Ω

18.31 800 Ω

18.33 Proof

18.35 (a) $\begin{bmatrix} 1 & \mathbf{Z} \\ 0 & 1 \end{bmatrix}$, (b) $\begin{bmatrix} 1 & 0 \\ \frac{1}{\mathbf{Y}} & 1 \end{bmatrix}$

18.37 $\begin{bmatrix} -3.5 & \frac{5}{6}\Omega \\ -2.5\ \text{S} & 0.5 \end{bmatrix}$

18.39 $\begin{bmatrix} \dfrac{2}{2s+1} & \dfrac{1}{s} \\ \dfrac{(s+1)(3s+1)}{s} & 2+\dfrac{1}{s} \end{bmatrix}$

18.41 $\begin{bmatrix} 2 & 2+j5 \\ j & -2+j \end{bmatrix}$

18.43 $z_{11} = \dfrac{A}{C}, z_{12}\dfrac{AD-BC}{C}, z_{21} = \dfrac{1}{C}, z_{22} = \dfrac{D}{C}$

18.45 Proof

18.47 (a) $\begin{bmatrix} 1 & -2 \\ -2 & 4.4 \end{bmatrix}$ S, (b) $\begin{bmatrix} 2.2 & 0.5\ \Omega \\ 0.2\ \text{S} & 0.5 \end{bmatrix}$

18.49 (a) $\begin{bmatrix} 1.786 & 0.7143 \\ 0.3571 & 2.143 \end{bmatrix}\Omega$, (b) $\begin{bmatrix} 1.667\ \Omega & 0.3333 \\ -0.1667 & 0.4667\ \text{S} \end{bmatrix}$,
(c) $\begin{bmatrix} 3 & 5\ \Omega \\ 1.4\ \text{S} & 2.5 \end{bmatrix}$

18.51 $\begin{bmatrix} 40 & 0 \\ 105 & 40 \end{bmatrix}$ kΩ, $\begin{bmatrix} 0.381 & 15.24\ \text{k}\Omega \\ 9.52\ \mu\text{S} & 0.381 \end{bmatrix}$

18.53 $\begin{bmatrix} \dfrac{1}{3} & -\dfrac{1}{3} \\ -\dfrac{1}{3} & \dfrac{2}{3} \end{bmatrix}$ S

18.55 $\begin{bmatrix} 1.25 & 0.75\ \Omega \\ 0.75\ \text{S} & 1.25 \end{bmatrix}$

18.57 $\begin{bmatrix} 0.063+j0.1954 & -0.103+j0.144 \\ -0.103+j0.1446 & 0.183-j0.205 \end{bmatrix}$ S

18.59 $\begin{bmatrix} 0.06\ \text{S} & -1.3 \\ 0.7 & 23.5\ \Omega \end{bmatrix}$

18.61 $\begin{bmatrix} 7 & 12\ \Omega \\ 4\ \text{S} & 7 \end{bmatrix}$, $\dfrac{12}{7}\Omega$

18.63 $\begin{bmatrix} 0.1269 & 0.01154 \\ 0.01154 & -0.03923 \end{bmatrix}$ S

18.65 $\begin{bmatrix} 4.669\angle -136.7^\circ & 2.53\angle -108.4^\circ \\ 2.53\angle -108.4^\circ & 1.789\angle -153.4^\circ \end{bmatrix}\Omega$

18.67 $\begin{bmatrix} 1.5 & -0.5 \\ 3.5 & 1.5 \end{bmatrix}$ S

18.69 $\begin{bmatrix} 1.4 & -0.8\ \Omega \\ 1.4\ \text{S} & -1.8 \end{bmatrix}$

18.71 $\begin{bmatrix} 2.727\ \text{S} & 0 \\ 0 & 0 \end{bmatrix}$

18.73 $Z_{\text{in}} = \dfrac{y_{22} + Y_L}{\Delta y + y_{11} Y_L}$, $Z_{\text{out}} = \dfrac{y_{11} + Y_s}{\Delta y + y_{22} Y_s}$, $A_i = \dfrac{-y_{21} Y_L}{\Delta y + y_{11} Y_L}$, $A_v = \dfrac{-y_{21}}{y_{22} + Y_L}$

18.75 (a) 250 kΩ, (b) −3333, 20, 65 kΩ, (c) −13.33 V

18.77 −17.1, 89.29, 25.63 kΩ, 182.9 kΩ

18.79 2×10^5, 200 Ω

18.81 See Fig. E.36.

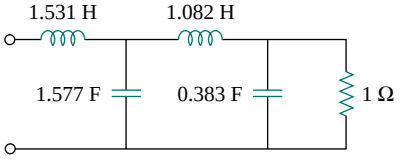


Figure E.36 For Prob. 18.81.

18.83 Proof